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# ORIGIN AND SIGNIFICANCE OF SEX.

BY C. C. NUTTING.

This paper is not presented as a contribution to our knowledge of the subject of the origin of sex, so much as an attempt to express concisely a theory of sex drawn from various sources, but principally from a work on the "Evolution of Sex" by Geddes & Thomson, a work which seems to me to mark an epoch in the science of philosophical biology.

My excuse for presenting this subject before you to-night lies in the fact that it has been my fortune within the past year to personally investigate the origin of the sex-elements in one group of animals, the hydroids, and to follow in the footsteps of that great master August Weismann, whose studies have given such an impetus to the search for truth in the realm of sex and heredity.

My own studies have resulted in a conviction that there is truth in the theory advanced by Geddes & Thomson, and my effort this evening will be to state this theory, in a slightly modified form, in a series of definite propositions, each one of which I believe to be defensible, if not invulnerable.

First, however, it will be necessary to call to your minds the most important facts concerning reproduction among the one-celled animals, or *Protozoa*.

The simplest form of reproduction is that of the amoeba, in which there is a simple division of the body mass of the parent cell into two portions, each of which becomes an independent organism. This is known as the process of reproduction by fission.

Turning to a somewhat higher group of *Protozoa* we find another step introduced in the reproductive process. If we study the Paramecium, for instance, we will find that it multiplies by fission, as does the amoeba, but that at intervals another process takes place, two individuals becoming adherent, the cell walls in the region of contact being dissolved as punctured, and an interchange of the protoplasm taking place. After this the individuals separate and the process of fission is renewed, and goes on for many generations. Ultimately, however, the process of conjugation is again resorted to.

In certain of the *Vorticellidæ* the reproductive process is still further complicated by the fact that the fission is not simple but multiple, one of the halves resulting from simple fission again dividing into a number of small ciliated bodies, each of which is capable of uniting with a normal vorticella in the process of conjugation.

In certain Acinetans the multiple fission is internal, the parent cell having its contents broken up into a number of ciliated bodies, which escape through the ectosarc.

We thus see that in going from the lower to the higher Protozoa we find the reproductive process growing more and more complicated. First in the amoeba we find simple fission, then in the Paramecium we find simple fission plus conjugation. In the vorticella we have simple fission plus multiple fission plus conjugation. In the acinetan we find simple fission plus internal multiple fission plus conjugation.

Such, then, are the facts. We now turn to seek an explanation.

*Anabolism* is the constructive, conservative, potential energy of the cell.

*Katabolism* is expressed in the destructive expenditure of this energy in active or kinetic processes.

The growth of any normal cell has a necessary limit due to a purely physical cause. The mass increases as the cube of the diameter, while the surface increases only as the square. The surface performs the function of respiration, but it cannot perform this function for an unlimited mass any more than a cubic inch of lung can perform respiration for a full grown man.

As a cell increases in size its mass increases more rapidly than its surface, until a point is reached beyond which it can not grow, because the surface can supply no more oxygen. It is worked to its limit, and can not respond to increased demands. At this stage there are three possibilities:

*First.*—Death, which would end the question.

*Second.*—Stationary balance, which is impossible.

*Third.*—Katabolism, which would cause the cell to disappear, or anabolism would recur at a certain point, and we would thus have an alternation or rhythm of katabolic and anabolic states.

This is logically conceivable, but it would debar the possibility of reproduction, and the individual cell would be theoretically immortal, but as a matter of fact would be destroyed ultimately by accidental means.

If, when the cell had reached the limit of size, it should divide, either accidentally or otherwise, there would result two individuals, both small enough to admit of an expression of anabolism in growth.

There would thus be two organisms to hold the fact of specific existence instead of one.

Therefore, any cell which would divide would have double the chance of perpetuation that a single cell would.

In other words, cells capable of spontaneous or mechanical fission would be selected and preserved by natural selection.

Let 1,000 generations proceed thus by simple division or fission. By this time considerable differences would exhibit themselves in the descendants of our original cell, owing to differences in environment and food supply.

One line of cells would be abundantly fed, would grow *large, inactive, anabolic.* Another line would be insufficiently nourished, and would grow smaller, more active, *katabolic.*

Taking the large anabolic cells, we find:

*First.*—They tend to become more and more inactive. (Activity may express itself either in motion or cell division.)

*Second.*—The anabolic cells accordingly tend to become quiescent on the one hand, and to cease dividing on the other.

*Third.*—This tendency would ultimately result in death, if not in some way counteracted.

Taking the smaller katabolic cells, we find:

*First.*—They tend to decrease in size.

*Second.*—They tend to become more and more active.

*Third.*—Their expenditures would eventually bankrupt them, they would be worn out, would die of exhaustion.

Taking the two kinds of cells we find:

*First.*—One needs something that can express itself in cell division, *Katabolism.*

*Second.*—The other needs nourishment which would express itself in growth, *Anabolism.*

In other words:

One is full and dying of plethora.

The other is hungry and dying of excessive expenditure of energy.

It would evidently be a good thing for them to pool their issues.

This is effected by the process of conjugation, whereby:

*First.*—The small, active, katabolic cell imparts its energy (kinetic) to the large passive cell, and that energy expresses itself in *cell division.*

*Second.*—The large, passive, anabolic cell imparts to the daughter cells its anabolic propensities which express themselves in *growth.*

In other words:

The anabolic cell receives the impetus necessary to cell division or fission, and the katabolic cell receives nourishment and the tendency to grow.

What brings them together?

*Hunger*, or its equivalent.

Hunger is a fundamental property of all things that need nourishment.

It is therefore a property of katabolic cells. The small, active cells need nourishment. The large, anabolic cells are packed full of nourishment.

*Example—Acinetan.*

An intensification of this process would be brought about in time by natural selection and would result in *multiple fission*, external and internal, which is the highest expression of sex found among the Protozoa.

### SEX IN THE METAZOA.

*Hydroid as a Type.*—The male cells originate from amoeboid endodermal cells which differentiate along the line of katabolism. They divide repeatedly and eventually become the smallest and most active cells in the colony. The female cells originate from amoeboid endodermal cells which differentiate along the line of anabolism. They grow excessively and become passive and circular in outline. They eventually become the largest and least active cells in the body.

These two cells unite, or the smaller seeks the larger and is absorbed in it. As a result:

*First.*—The small, active cell imparts its kinetic energy to the large, passive cell, and that energy expresses itself in cell division.

*Second.*—The large, passive, anabolic cell imparts to the daughter cells its anabolic propensities, which express themselves in growth.

By the growth and division of cells every organism, from the hydroid to man himself, attains its perfection.

It will be seen from what has been said that there is no fundamental difference between the reproductive processes in the Protozoa and Metazoa. All of the complicated machinery associated with sex in the higher forms are merely accessory to the fundamental fact of the meeting of two cells, an intermingling of protoplasm and a subsequent cell division, all of which phenomena are essentially present in the conjugation and fusion of the *Paramecium* for instance.

As to the *significance of sex*, it is not sufficient to say that it serves to perpetuate the species. It does much more. It serves to *improve* species in that the commingling of the characteristics of two parents furnishes the main potentiality for individual variation among the offspring. Indeed, Weismann stoutly maintains that we have here the only cause for individual variation upon which natural selection can act, and he believes that evolution would be impossible among sexless animals. However this may be, it is clearly true that progress is much more rapid and certain by virtue of the fact that most individuals animals have a *father and a mother*.

It would be impossible in the limits of this paper to discuss the tremendous ethical, social and moral significance of sex. It must suffice to suggest that altruism had its birth in the world when brutes first cared for and protected their helpless young, and that through the social relations of parent and child, husband and wife, all that is purest and best in human affairs found its inception and its impetus.